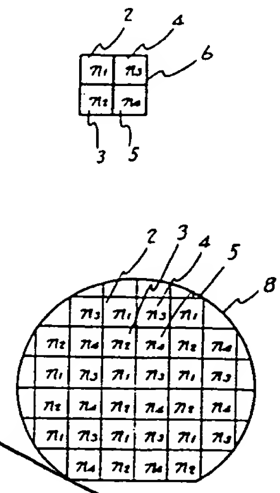
(54) MANUFACTURE OF SEMICONDUCTOR INTEGRATED CIRCUIT DEVICE
(11) 59-215717 (A) (43) 5.12.1984 (19) JP
(21) Appl. No. 58-90906 (22) 24.5.1983
(71) NIPPON DENKI K.K. (72) YUUJI NODA
(51) Int. Cl³. H01L21/02



PURPOSE: To improve the production efficiency of the small quantity production of a large number of sorts by a method wherein semiconductor integrated circuit devices are produced from a wafer on which not less than two types of pellets are arranged.

CONSTITUTION: A unit form pellet 6 is composed of, for instance, four types of composition element pellets n1(2), n2(3), n3(4) and n4(5) which have identical outside dimensions and whose inside patterns are different from each other. A wafer 8 is composed by arranging such unit form pellets 6. If the wafer 8 is introduced for production, from (T/N)×4 wafers of one sort, four types of devices can be produced. Compared to the conventional method, the number of wafers to be treated is quadrupled but the number of sorts of wafers is 1/4. With this constitution, the production efficiency of the small quantity production of a large number of sorts can be improved significantly.

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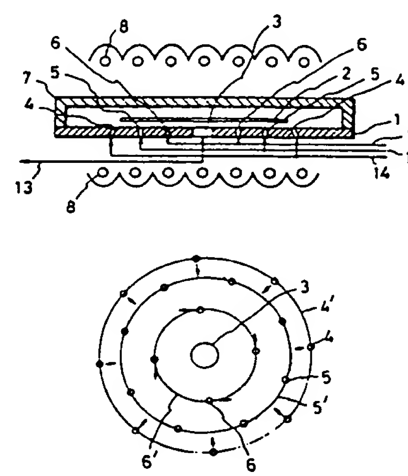
(54) INFRARED HEAT TREATMENT APPARATUS FOR SEMICONDUCTOR WAFER
(11) 59-215718 (A) (43) 5.12.1984 (19) JP
(21) Appl. No. 58-89139 (22) 23.5.1983
(71) KOKUSAI DENKI K.K. (72) KAZUO HIURA(2)
(51) Int. Cl³. H01L21/18,H01L21/26



PURPOSE: To reduce a heat loss and even the temperature of the surface of a wafer by a method wherein floating gas outlets and rotating gas outlets are provided, and a wafer being gas-supported is rotated during a predetermined period of heat treatment.

CONSTITUTION: A wafer 2 is disposed at a predetermined position. Thereupon, the wafer 2 is rotated in a state of floatation, while being in close proximity to the surface of a retaining plate 1, by virtue of the gas jetting out of floating gas outlets 5. The wafer 2 is furthermore forced from every direction toward the central portion by the gas emitting from positioning gas outlets 4. Then the wafer 2 halts and remains static at a position where the pushing forces are well balanced. The gas is spouted from rotating gas outlets 6 which are arranged at equal spacings on the inside concentric circle neighbouring to the circle defined by the gas outlets 5. As a result, the wafer 2 being in a state of flotation rotates in such manner that the center of the wafer 2 is retained by means of the positioning gas. In this condition, the infrared irradiation is effected, whereby there is no partial thermal loss caused by the contact with solid substances and it is possible to make uniform the temperature of the wafer surface.

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(54) PREVENTION OF UNDESIRABLE SEPARATION OF SILICON THIN FILM
(11) 59-215719 (A) (43) 5.12.1984 (19) JP
(21) Appl. No. 58-89230 (22) 23.5.1983
(71) KOGYO GIJUTSUIN (JAPAN) (1) (72) KAZUNOBU TANAKA(2)
(51) Int. Cl³. H01L21/205,H01L31/04

PURPOSE: To prevent the separation of a silicon thin film by previously adjusting such that there is no existence of oxygen atoms on the surface of an oxide substrate.

CONSTITUTION: There are two adjusting methods by which the surface of an oxide substrate is made free from oxigen atoms. One of the methods is such that the oxygen substrate is coated such as not to be directly attacked by F atoms. The other method is to remove the oxygen atoms from the surface layer of the oxide substrate. Take the former method for instance, an Si:H thin film, which is equivalent to a coating layer on the order of 100Å, is formed on the oxide substrate by the use of a gas, such as monosilane, by means of glow discharge decomposition. Thereafter, the formation of a desired Si:H:F thin film is effected by the glow discharge decomposition of silicon tetrafluoride plus hydrogen gas, thus making it possible to prevent the separation of the silicon thin film.

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⑫公開特許公報（A）　　昭59—215718

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㊺半導体基板の赤外線熱処理装置

㉑特　　願　昭58—89139

㉒出　　願　昭58(1983)5月23日

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明　　細　　書

1. 発明の名称

半導体基板の赤外線熱処理装置

2. 特許請求の範囲

1. 半導体基板を赤外線で加熱する熱処理装置において、半導体基板を浮揚状態で水平に保持するようにガスを噴出せしめる噴出口を設けかつ前記赤外線を透過する保持板と、この保持板上に浮揚状態で保持されている前記半導体基板を内部に収納するように前記保持板の上側を被いかつ前記赤外線を透過する上蓋と、前記保持板の下側および前記上蓋の上側から浮揚状態で保持された前記半導体基板にそれぞれ赤外線を照射する赤外線照射装置からなり、前記保持板には前記半導体基板を浮揚状態で保持する位置の中心点に前記浮揚状態を維持したガスの排出口と、この排出口を中心として前記半導体基板の外径よりわずかに大きい円周上に分散配置しかつ前記保持板に対する垂線より一定角度だけ前記排出口側に傾斜した方向に設けられた複数の位置決めガス噴出口と、この位置決めガス噴出口を通る前記円周と前記ガス排出口との中間の位置にある同心円上に均等に分散配置されかつ一定方向に設けられた複数の浮揚ガス噴出口と、この浮揚ガス噴出口を通る前記円周と前記ガス排出口との中間の位置にある同心円上に均等に分散配置されてこの同心円の切線方向に一定角度にかつ前記ガス排出口の位置から見て同一方向に傾斜して設けられた回転用ガス噴出口とを具備したことを特徴とする半導体基板の赤外線熱処理装置。

2. 特許請求の範囲第1項記載の半導体基板の赤外線熱処理装置において、前記複数の浮揚ガス噴出口が前記保持板に対し垂直方向に設けられてある前記半導体基板の赤外線熱処理装置。

3. 特許請求の範囲第1項記載の半導体基板の赤外線熱処理装置において、前記複数の浮揚ガス噴出口が前記保持板に対し一定角度だけ前記排出口側に傾斜して設けられてある前記半導体基板の赤外線熱処理装置。

4. 半導体基板を赤外線で加熱する熱処理装置に

おいて、半導体基板を浮揚状態で水平に搬送および保持するようにガスを噴出せしめる噴出口を設けかつ前記赤外線を透過する保持板と、この保持板上に浮揚状態で搬送および保持されている前記半導体基板を内部に収納するように前記保持板の上側を被いかつ前記赤外線透過する上蓋と、前記保持板の下側および前記上蓋の上側から浮揚状態で保持された前記半導体基板にそれぞれ赤外線を照射する赤外線照射装置からなり、前記保持板には前記半導体基板を浮揚状態で保持する位置の中心点に前記浮揚状態を維持したガスの排出口と、このガス排出口の中心を通る直線上に列をなして一定間隔でかつこの直線を含み前記保持板に垂直な平面上で一定方向に傾斜した搬送ガス噴出口と、この搬送ガス噴出口の列に平行しかつ前記半導体基板を保持する位置に保持された半導体基板の外周に相当する前記保持板上の円周に接しこの円周の両側に1本ずつある2本の直線上に列をなして一定間隔でかつ一定角度だけ前記搬送ガス噴出口の列の方に傾斜して設けた誘導ガス噴出口と、この誘導ガス噴出口の列と前記搬送ガス噴出口の列との中間でこれらの列に平行して列をなしかつ一定方向にガスを噴出させる浮揚ガス噴出口と、前記半導体基板を保持すべき位置に半導体基板の位置決めを行なうためにこの半導体基板の外周よりわずかに大きい前記保持板上の円周上に分散配置しかつ前記ガス排出口の中心を通り前記搬送ガス噴出口の列に垂直な平面の方向に傾斜して設けられた位置決めガス噴出口と、前記ガス排出口と前記位置決めガス噴出口を通る円周との中間の同心円上に均等に分散配置し同心円の切線方向に一定角度でかつ前記排出口の位置から見て同一方向に傾斜して設けられた回転用ガス噴出口とを具備したことを特徴とする半導体基板の赤外線熱処理装置。

5. 特許請求の範囲第4項記載の半導体基板の赤外線熱処理装置において、前記複数の浮揚ガス噴出口が前記保持板に対して垂直方向に設けられてある前記半導体基板の赤外線熱処理装置。

6. 特許請求の範囲第4項記載の半導体基板の赤外線熱処理装置において、前記複数の浮揚ガス噴出口が前記保持板に対して一定角度だけ前記搬送ガス噴出口の列の方向へ傾斜している前記半導体基板の赤外線熱処理装置。

3. 発明の詳細な説明

本発明は半導体装置の製造過程において赤外線によって半導体基板を急速加熱し、熱処理を行なう装置に関するものである。

従来から赤外線照射によって被加熱物である半導体基板(以下ウエーハという)を加熱する方法はすでに実施されている。しかし一般にはこの方法はサセプタ上にウエーハを載置し、上面から赤外線を照射して加熱しているので、ウエーハの上面が急速に温度上昇し、熱容量の大きいサセプタに接しているウエーハの下面の温度上昇が遅れるためにウエーハ内で上面と下面との間に大きな温度勾配が生じ、イオン注入されたウエーハなどでは注入されたイオンの分布変化を生じる原因ともなりかねない。これをさけるためにサセプタを石英などの赤外線透過物質で作り、このサセプタの下側からも赤外線照射を行なえば上記の温度勾配を減少させることが出来るが、石英などの赤外線吸収率は低く、サセプタが直接発熱しにくく、ウエーハ下面からサセプタへ熱伝導によって熱量が逃げるために前記の温度勾配はさほど改善されない。この温度勾配は前記の注入イオン分布の変化原因のほかにもウエーハのそりなどの欠陥原因ともなり、好ましくない。

この欠陥原因をさけるためにサセプタ上に3点程度の突起を設け、この突起上にウエーハを載置すれば前記熱伝導による前記温度勾配は相当程度除去出来るが、赤外線源の配置間隔や赤外線の放射量のばらつきなどにより、ウエーハ表面での温度勾配を除去することは出来ない。このウエーハ表面の温度勾配を除去するためにはサセプタを回転させれば良いが装置が複雑となる。またこの方法を量産用の連続熱処理装置に使用するためにはウエーハの複雑なローディングおよびアンローディング装置が必要となるうえ、これらの装置のハンドリング機構の熱容量が大きいために昇温およ

び冷却時間が必要となり、急速な動作が出来ず、ウエーハの処理枚数を低下させることになる。

本発明はこのような問題点を解決するためになされたもので、ウエーハ内の温度勾配を発生させずに急速加熱を行なえ、かつ量産用の流れ生産にも容易に適用出来る熱処理装置を提供するものである。以下図面により詳細に説明する。

第1図は本発明の一実施例の装置で熱処理を行なうウエーハを保持する中心点を通る垂直断面図である。石英などの赤外線を透過し易い材料で作られた保持板1にはウエーハ2を保持する位置の中心点にウエーハ2を浮揚状態に維持したガスの排出口3が設けられている。この排出口3を中心とし、この上に保持されるウエーハ2の外周よりわずかに大きい円周4′上に分散配置され、かつ前記排出口3側に傾斜して複数個の位置決めガス噴出口4が設けられている。第2図は保持板1上の排出口3および位置決めガス噴出口4および後述する各種のガス噴出口の配置を示す平面図である。つぎに複数個の位置決めガス噴出口4の並んだ円周4′と排出口3との中間に位置する同心円5′上に均等に分散配置された複数個の浮揚ガス噴出口5が設けられている。これらの浮揚ガス噴出口5は保持板1に対して全数が垂直か、もしくは全数が排出口3側に一定角度だけ傾斜して設けられている。第1図は垂直の場合が示してある。さらにこれらの浮揚ガス噴出口5を通る前記円周5′と排出口3との中間の位置にある同心円6′上に均等に分散配置されてこの同心円の切線方向に一定角度にかつ前記排出口3の位置から見て同一方向に傾斜して回転用ガス噴出口6が設けられている。また保持板1の上側は浮揚状態で保持されているウエーハ2を収納する形でかつ石英などの赤外線を透過し易い材料で作られた上蓋7で被われている。この上蓋7の上側および保持板1の下側にはそれぞれ赤外線照射装置8が前記浮揚状態で保持されているウエーハ2を照射するように設けられている。なお、前記の排出口3、位置決めガス噴出口4、浮揚ガス噴出口5および回転用ガス噴出口6にはそれぞれ石英などの赤外線を透過し易い材料で作られた導管13，14，15および16が接続してあって、必要な時に必要なガスを噴出および排出することが出来るようになっている。

つぎに、本発明の他の実施例について説明する。第3図は保持板1上の排出口3および各種のガス噴出口の配置を示す平面図である。排出口3および回転用ガス噴出口6は前記実施例と同様であるので、説明を省略する。排出口3の中心を通る直線9′上に列をなし、一定間隔でかつ一定方向に傾斜して複数の搬送ガス噴出口9が設けられている。さらにこの搬送ガス噴出口9の列と平行し、かつ排出口3を中心にして保持されるウエーハの外周に相当する保持板1上の円周12′の両側に接する2本の直線10′上に等間隔でかつ搬送ガス噴出口9の列の方向に傾斜して複数の誘導ガス噴出口10が設けられている。また搬送ガス噴出口9の列の両側に、誘導ガス噴出口10の列との間でこれらの列に平行した直線11′上に一定間隔で保持板1に垂直もしくは搬送ガス噴出口9の列の方向に傾斜して浮揚ガス噴出口11が設けられている。さらに前記誘導ガス噴出口10の列が接する保持板1上の円周上で、搬送ガス噴出口9の列と浮揚ガス噴出口11の列との中間部分にはそれぞれ同数の位置決めガス噴出口12が設けられており、これらの位置決めガス噴出口12は排出口3を通り搬送ガス噴出口9の列に垂直な平面の方向に傾斜して設けられている。以上の各噴出口のうち誘導ガス噴出口10および浮揚ガス噴出口11で第1のグループを構成し、位置決めガス噴出口12のうち搬送されて来る手前側12−1が第2のグループを、同じく搬送されて行く側（後側）12−2が第3のグループを、搬送ガス噴出口9が第4のグループを、回転用ガス噴出口が第5のグループを構成しており、各グループごとに別々に保持板1の下側で石英などの赤外線を透過し易い材料で作られた導管が接続してあり、必要な時に必要なガスを噴出および排出することが出来るようになっている。このような保持板1のほかに上蓋7および赤外線照射装置8は前記実施例と同

様であるので説明は省略する。

つぎに本発明の装置の動作について説明する。まず、第1の実施例について説明する。この実施例の場合は保持板1にはウエーハを搬送する機能はなく、一定の場所に浮揚保持して赤外線による加熱を行うものである。ウエーハ2を載置する前に各噴出口から必要量のガス（例えば窒素ガスなど）を噴出させておく。噴出する方向は前記説明の通り噴出口の向いて居る方向であり、保持板1の面に対し垂直な方向から第2図の矢印方向に約30度傾斜させてある。なお浮揚ガス噴出口5は垂直方向か約30度傾斜させるか、何れか一方を選択すればよいので、第2図では矢印を付してない。このような状態のときにウエーハ2を所定の位置に置くと、5から噴出する浮揚ガスにより保持板1上に浮揚状態で保持される。浮揚する高さは浮揚ガスの噴出量によって調節出来るので、0.5㎜以下の浮揚で十分である。さらに4から噴出する位置決めガスにより、ウエーハ2にはそれぞれの位置決めガス噴出口4からウエーハ2の中心方向に押されている。したがってこの噴出口が分散配置してあるので、ウエーハ2は各方向から中心部に押され、これらの力のバランスの取れた所で静止する。この静止点が排出口3を中心とする円と同心円となるように噴出口が配置されて居れば良いので、第1の実施例の場合は均等に分散配置してあれば良い。

つぎにウエーハ2の回転について説明する。浮揚ガス噴出口列の内側の同心円上に均等に分散配置された回転ガス噴出口6から垂直方向に対して約30度の傾斜した方向に回転ガスを噴出すると、浮揚状態のウエーハ2は位置決めガスによって中心を保持された状態で回転する。

このような状態で上蓋7を閉じ、赤外線照射装置8を点灯すれば、ウエーハ2は上下から赤外線の照射を受け、急速に加熱される。実施例では赤外線のエネルギー照射密度を20～30W/㎠程度とするとウエーハ2は約10秒で常温から1000℃以上の高温にすることが出来る。またウエーハ2の上下両面の温度差は上下の赤外線照射装置8へ供給する電力を調節することにより、容易に均衡を保たせることが出来る。さらにウエーハ2を回転させているので、赤外線照射装置8の配置および赤外線照射量のばらつきによるウエーハ2の同一表面上の温度差もなくして、均一に加熱することが出来る。なお、ガスの噴出によるウエーハ2の下面の冷却は、その冷却量に相当するだけ下側の赤外線照射装置8の照射量を多くすれば良い。

つぎに第2の実施例の動作について説明する。第3図は本実施例の保持板1上の排出口3および各噴出口の配置図で、矢印はその噴出口の方向が保持板1上の垂線から傾斜している方向を示しているもので、本実施例でも傾斜角は垂線から約30度としてある。

これらの噴出口のうち最初からガスが噴出しているのは前記第1のグループの誘導ガスおよび浮揚ガスの噴出口10および11で、このグループのガスは動作中常時噴出している。つぎに第3のグループの位置決めガスを12－2から噴出させ、第4のグループの搬送ガスを9から噴出させてから前記2列の誘導ガス噴出口10の間で第3図の右端にウエーハ2を置くと、ウエーハ2は浮揚ガスで0.5㎜程度保持板1から浮上し、誘導ガスで搬送路の中心線上に誘導されながら搬送ガスで搬送されて第3図の中央部分の排出口3の真上まで来る。この位置に来るとすでに12－2から噴出している第3グループの位置決めガスの噴出流により進行が止められる。このときに第4グループの搬送ガスの噴出を止めると同時に第2グループの位置決めガスおよび第5グループの回転用ガスをそれぞれの噴出口12－1および6から噴出させる。この状態ではウエーハ2は第1グループの浮揚ガスで保持板1から浮上したまま、同じく第1グループの誘導ガスおよび第2、第3グループの位置決めガスによって排出口3の真上に中心を置く位置に位置決めされ、第5グループの回転用ガスにより回転を始める。

なおこの時にはすでに赤外線照射装置8は点灯されているので、一定位置で浮揚状態で回転しているウエーハ2は上下両面から急速に、かつ均等

に加熱される。

つぎに所定時間熱処理を行った後ウエーハ2を搬出するために、第3グループの位置決めガスの噴出を止めると同時に第4グループの搬送ガスの噴出を再開すれば、12−1から噴出している第2グループの位置決めガスと第4グループの搬送ガスとによって第3図の左方向へ始動し、以後搬送ガスのみにて左端まで移動して行く。

なお第5グループの回転用ガスはウエーハ2を回転させる時のみ噴出させても、または第1グループの誘導ガスおよび浮揚ガスのように常時噴出させていても何れでも良い。

この第2の実施例の場合には第3図に示すウエーハ2の走行区間の右端および左端に本出願人が出願した特願昭57−103524号「半導体基板の連続熱処理方法および装置」に記載したウエーハ供給カセットおよびウエーハ収納カセットを設ければカセットからカセットまでの動作の自動化を容易に実施することが出来る。

以上のように、本発明の装置ではウエーハ2は噴出ガスによって浮上しているので、固形物との接触による部分的な熱損失がなく、さらに所定の熱処理期間中は回転しているので、赤外線照射装置8の配置状況および照射量のばらつきなどによるウエーハ2の表面の温度むらも均一化出来る。また浮揚搬送が可能であるので、連続的に熱処理する装置の自動化も容易に行うことが出来る。さらに熱容量の大きい部分を加熱する必要がないので、急速加熱、急速冷却も容易に実施出来るなど、実用効果は極めて大きい。

4.図面の簡単な説明

第1図は本発明の一実施例の装置のウエーハを保持する中心点を通る垂直断面図である。第2図は第1図の装置の保持板上のガスの排出口および噴出口の配置図である。第3図は本発明の他の実施例の装置の保持板上のガスの排出口および噴出口の配置図である。

図において、1は保持板、2はウエーハ、3は排出口、4は位置決めガス噴出口、5は浮揚ガス噴出口、6は回転用ガス噴出口、7は上蓋、9は搬送ガス噴出口、10は誘導ガス噴出口、11は浮揚ガス噴出口、12−1，12−2は位置決めガス噴出口である。

特許出願人　国際電気株式会社
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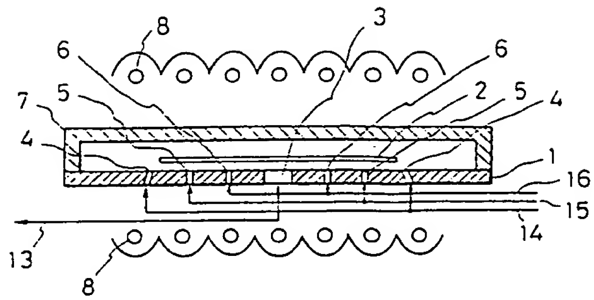
第 1 図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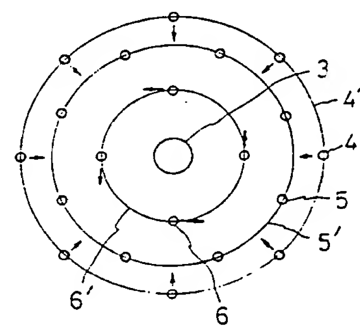
第 2 図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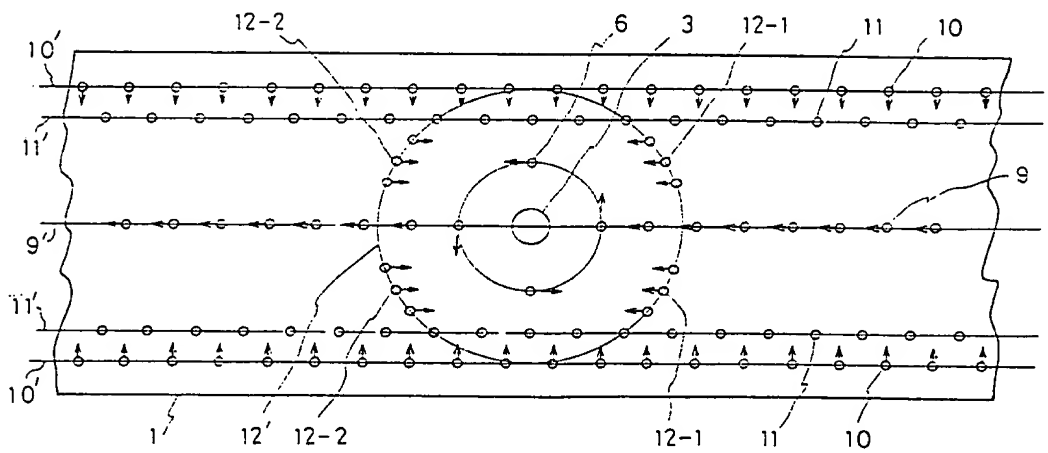
第 3 図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INFRARED HEAT TREATMENT DEVICE FOR SEMICONDUCTOR SUBSTRATE
[Han'doutai Kiban' no Sekigaisen' Netsushori Souchi]

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SPECIFICATION /75*

1. Title of the Invention

Infrared Heat Treatment Device for Semiconductor Substrate

2. Claims

1. A heat treatment device for heating semiconductor substrates by using infrared light characterized by: being comprised of a retaining board that is provided with spray nozzles for spraying gas in order to horizontally retain a semiconductor substrate in a floating state and that transmits said infrared light, an upper lid that covers the upper side of said retaining board in a manner such that said semiconductor substrate retained over the retaining board in a floating state is stored inside and that also transmits said infrared light, and infrared irradiation devices that irradiate infrared light onto said semiconductor substrate retained in a floating state from the bottom side of said retaining board and from the top side of said upper lid; and said retaining board being equipped with

a discharge port for the gas, which retains said floating state, at the center point of the location at which said semiconductor substrate is retained in a floating state,

*Numbers in the margin indicate pagination in the foreign text.

a plurality of positioning gas spray nozzles that are located in a dispersed manner on a circle slightly larger than the outer diameter of said semiconductor substrate with the discharge port at the center and that are provided in a manner such that they are inclined toward said discharge port side by a set angle from a line perpendicular to said retaining board,

a plurality of flotation gas spray nozzles that are evenly dispersed and provided in a set direction on a concentric circle located between said circle that passes through the positioning gas spray nozzles and said gas discharge port, and

rotation gas spray nozzles that are evenly dispersed and provided on a concentric circle that is located between said gas discharge port and said circle that passes through the flotation gas spray nozzles in a manner such that they are inclined by a set angle in the tangential-line direction of the concentric circle and in the same direction when viewed from the position of said discharge port.

2. Said infrared irradiation treatment device for semiconductor substrates of Claim 1 in which said plurality of flotation gas spray nozzles are provided in the direction perpendicular to said retaining board.

3. Said infrared irradiation treatment device for semiconductor substrates of Claim 1 in which said plurality of

flotation gas spray nozzles are provided in a manner such that they are inclined toward said discharge port by a set angle with respect to said retaining board.

4. A heat treatment device for heating semiconductor substrates by using infrared light characterized by: being /76 comprised of a retaining board that is provided with spray nozzles for spraying gas in order to horizontally transfer and retain a semiconductor substrate in a floating state and that transmits said infrared light, an upper lid that covers the upper side of said retaining board in a manner such that said semiconductor substrate transferred and retained over the retaining board in a floating state is stored inside and that also transmits said infrared light, and infrared irradiation devices that irradiate infrared light onto said semiconductor substrate retained in a floating state from the bottom side of said retaining board and from the top side of said upper lid; and said retaining board being equipped with

a discharge port for the gas, which retains said floating state, at the center point of the location at which said semiconductor substrate is retained in a floating state,

transfer gas spray nozzles that form a row in a straight line that passes through the center of the gas discharge port and that are inclined in a set direction at constant intervals on a plane that includes this straight line and that is perpendicular to said

retaining board,

guiding gas spray nozzles provided at constant intervals in a manner such that they are inclined toward the row of said transfer gas spray nozzles by a set angle and such that they form rows in two straight lines that are parallel to the row of the transfer gas spray nozzles, that touch said circle on the retaining board that corresponds to the outer circumference of the semiconductor substrate retained at said location for retaining the semiconductor substrate, and that are each located on either side of the circle,

flotation gas spray nozzles that form rows between and in parallel with the rows of the guiding gas spray nozzles and the row of said transfer gas spray nozzles and that spray gas in a set direction,

positioning gas spray nozzles that, in order to position the semiconductor substrate to said location at which the semiconductor should be retained, are located in a dispersed manner on a circle on said retaining plate slightly larger than the outer circumference of said semiconductor substrate and that are provided in a manner such that they are inclined toward a plane that goes through the center of said gas discharge port and that is perpendicular to the row of said transfer gas spray nozzles, and

rotation gas spray nozzles that are evenly dispersed and provided on a concentric circle that is located between said gas

discharge port and said circle that passes through said positioning gas spray nozzles in a manner such that they are inclined by a set angle in the tangential-line direction of the concentric circle and in the same direction when viewed from the position of said discharge port.

5. Said infrared irradiation treatment device for semiconductor substrates of Claim 4 in which said plurality of flotation gas spray nozzles are provided in the direction perpendicular to said retaining board.

6. Said infrared irradiation treatment device for semiconductor substrates of Claim 4 in which said plurality of flotation gas spray nozzles are provided in a manner such that they are inclined toward the row of said transfer gas spray nozzles by a set angle with respect to said retaining board.

3. Detailed Explanation of the Invention

The present invention pertains to devices that rapidly heat semiconductor substrates by means of infrared light in order to perform a heat treatment in the manufacturing process of a semiconductor device.

A method in which a semiconductor substrate (hereinafter referred to as a wafer), which is the object of heating, is heated by means of infrared irradiation has already been conventionally practiced. In general, however, a wafer is mounted on a susceptor

and heating is carried out by irradiating infrared light from the top according to this method. Therefore, the temperature of the top surface of the wafer increases rapidly, and the temperature increase of the bottom surface of the wafer that is in contact with the susceptor, which has a large heat capacity, is slowed down. This causes a large temperature gradation between the top and the bottom surfaces within the wafer, and this may become a cause for a distributional change of injected ions if the wafer has been injected with ions. In order to avoid this, the above-mentioned temperature gradation can be reduced by also irradiating infrared light from the bottom side of this susceptor by making the susceptor using an infrared transmitting material, such as quartz, but the infrared absorption rate of quartz, etc., is low, the susceptor is not likely to directly emit heat, the heat escapes from the wafer's bottom surface to the susceptor due to heat transmission, and therefore, the above-mentioned temperature gradation will not be improved very much. This temperature gradation is not desirable because it becomes a cause of defects, such as wafer warpage, in addition to the distribution change of the injected ions mentioned earlier.

In order to avoid this cause of defects, said temperature gradation caused by said heat transmission can be considerably reduced by providing protrusions at 3 points or so on the susceptor

and by mounting the wafer on these protrusions. However, the temperature gradation on the wafer surface cannot be reduced due to variations in the intervals of the locations and the infrared light irradiation amounts of the infrared light sources. By rotating the susceptor, this temperature gradation on the wafer surface can be eliminated, but this makes the device complex. Moreover, in order to utilize this method for a mass-production continuous heat treating device, complex wafer loading and unloading devices become necessary. Moreover, since the heat capacities of the handling mechanisms of these devices are high, temperature increase time and cooling time become necessary. Therefore, rapid movement is not /77 possible, and the number of wafers processed decreases.

The present invention was completed in order to solve such problems, and it supplies a heat treatment device capable of rapidly heating without generating a temperature gradation inside the wafer and capable of being applied easily to mass-production assembly lines. A detailed explanation will be given below based on drawings.

Figure 1 is a drawing of a vertical cross section that goes through the center point of the retained position of a wafer that is to be heat-treated by the device of one working example of the present invention. A retaining board [1] made from a material that easily transmits infrared light, such as quartz, has a discharge

port [3] for gas, which is used to retain the wafer in a floating state, provided at the center point of the retained position of the wafer [2]. A plurality of positioning gas spray nozzles [4] are located in a dispersed manner on a circle [4'] slightly larger than the outer periphery of the wafer [2], which is retained over the discharge port [3], with the discharge port [3] at the center and in a manner such that they are inclined toward said discharge port [3] side. Figure 2 is a plane view showing the locations of the discharge port [3], the positioning gas spray nozzles [4], and later-described various gas spray nozzles in the retaining board [1]. Next, on a concentric circle [5'] located between the circle [4'] on which the plurality of positioning gas spray nozzles [4] are arranged and the discharge port [3], a plurality of evenly dispersed flotation gas spray nozzles [5] are provided. These flotation gas spray nozzles [5] are provided in a manner such that all of them are perpendicular to the retaining board [1] or such that all of them are inclined by a set angle toward the discharge port [3] side. Furthermore, evenly dispersed rotation gas spray nozzles [6] are provided on a concentric circle [6'] that is located between the discharge port [3] and said circle [5'] that passes through the flotation gas spray nozzles [5] in a manner such that they are inclined by a set angle with respect to the tangential-line direction of the concentric circle and in the same

direction when viewed from the position of said discharge port [3]. The top side of the retaining board [1] is covered by an upper lid [7] made of a material that easily transmits infrared light, such as quartz, in a manner such that it stores the wafer [3] that is being retained in a floating state. Above the top side of this upper lid [7] and below the bottom side of the retaining board [1], infrared irradiation devices [8] are provided in a manner such that they irradiate onto said wafer [2] that is being retained in a floating state. Moreover, guide tubes, [13], [14], [15], and [16], that are made from a material that easily transmits infrared light, such as quartz, are connected to each of said discharge port [3], positioning gas spray nozzles [4], flotation gas spray nozzles [5], and rotation gas spray nozzles [6], and it is possible to spray or discharge required gas when necessary.

Next, another working example of this invention will be explained. Figure 3 is a plan view showing the arrangement of the discharge port [3] and various gas spray nozzles in the retaining board [1]. The discharge port [3] and the rotation gas spray nozzles [6] are the same as those in the above-mentioned working example, so their explanations will be omitted. On a straight line [9'] that goes through the center of the discharge port [3], a plurality of transfer gas spray nozzles [9] are provided in a row at constant intervals in a manner such that they are inclined in a

set direction. Moreover, on two straight lines [10'] that are parallel to said row of transfer gas spray nozzles [9] and that touch both sides of a circle [12'] on the retaining board [1] that is equivalent to the outer circumference of the wafer, which is being retained with the discharge port at the center, a plurality of guiding gas spray nozzles [10] are provided at equal intervals in a manner such that they are inclined toward the row of the transfer gas spray nozzles [9]. Moreover, on both sides of the row of transfer gas spray nozzles [9], flotation gas spray nozzles [11] are provided at constant intervals in a manner such that they are perpendicular to the retaining board [1] or inclined toward the row of transfer gas spray nozzles [9] on straight lines [11'] that are between and parallel to the rows of guiding gas spray nozzles [10]. Moreover, the same number of positioning gas spray nozzles [12] are provided between the row of transfer gas spray nozzles [9] and the rows of flotation gas spray nozzles [11] in the areas of the circle on the retaining board [1] touched by the rows of said guiding gas spray nozzles [10], and these positioning gas spray nozzles [12] are provided in a manner such that they are inclined in the direction of a plane that passes through the discharge port [3] and that is perpendicular to the row of transfer gas spray nozzles [9]. Among the above various spray nozzles, the guiding gas spray nozzles [10] and flotation gas spray nozzles [11] make up a first

group, the positioning gas spray nozzles [12] that are on the upstream side [12-1] of the transfer make up a second group, the positioning gas spray nozzles [12] that are on the downstream side (rear side) [12-2] of the transfer make up a third group, the transfer gas spray nozzles [9] make up a fourth group, and the rotation gas spray nozzles make up a fifth group. Below the retaining board [1], each group is separately connected to guide tubes made from a material that easily transmits infrared light, such as quartz, and it is possible to spray or discharge required gas when necessary. In addition to such a retaining board [1], the upper lid [7] and infrared irradiation devices [8] are the same as those of the above-mentioned working example, and their explanations will be omitted. /78

Next, the operation of the device of this invention will be explained. First, the first working example will be explained. In the case of this working example, the retaining board [1] does not have a function to transfer the wafer, and heating is carried out by means of infrared light by retaining the wafer in a floating state at a fixed location. Before mounting the wafer [2], required gas (such as nitrogen gas) is sprayed from each spray nozzle. The spraying directions are the directions in which the spray nozzles face as explained earlier, and they are inclined by about 30° in the directions of the arrows of Fig. 2 from the direction

perpendicular to the surface of the retaining board [1]. Since the flotation gas spray nozzles [5] can be selected to be either in the perpendicular direction or inclined by 30°, arrows are not assigned to them in Fig. 2. When the wafer [2] is placed at a prescribed location in such a condition, it becomes retained in a floating state over the retaining board by means of the flotation gas sprayed from [5]. The height of flotation can be adjusted by means of the spray amount of the flotation gas, and flotation of 0.5mm or less is sufficient. Moreover, by means of the positioning gas sprayed from [4], the wafer [2] is pressed toward the center of the wafer [2] from each of the positioning gas spray nozzles [4]. Since these spray nozzles are located in a dispersed manner, the wafer [2] is pressured toward the center from each direction and stops at a location at which the balance of the forces is achieved. The spray nozzles should be located in a manner such that this stop point becomes concentric to a circle that has the discharge port [3] at the center, and they should be located in an evenly dispersed manner in the case of the first working example.

Next, the rotation of the wafer [2] will be explained. When rotation gas is sprayed from the rotation gas spray nozzles [6], which are evenly dispersed on a concentric circle on the inner side of the flotation gas spray nozzle row, in a direction about 30° inclined from the vertical direction, the wafer [2] that is in a

floating state rotates while having its center maintained by means of the positioning gas.

By closing the upper lid [7] and turning on the infrared irradiation devices [8] in such a state, the wafer [2] receives infrared irradiation from the top and the bottom and becomes heated rapidly. In the working example, the temperature of the wafer [2] can be increased from a normal temperature to a high temperature of 1000°C or higher in about 10 seconds by setting the infrared light energy irradiation density to about 20~30W/cm^2. Moreover, as for the temperature difference between the top and bottom surfaces of the wafer [2], equilibrium can be provided easily by adjusting the electrical power supplied to the top and bottom infrared irradiation devices [8]. Moreover, since the wafer [2] is being rotated, heating can be performed evenly by also eliminating temperature differences on the same surface of the wafer [2] caused by variations in the locations and infrared irradiation amounts of the infrared irradiation devices [8]. As for the cooling of the bottom surface of the wafer [2] caused by the gas spraying, the irradiation amounts of the bottom-side infrared irradiation devices [8] should be increased by an amount proportionate to the cooling amount.

Next, the operation of the second working example will be explained. Figure 3 is a layout drawing of the discharge port [3]

and each spray nozzle on the retaining board [1] of this working example, and the arrows indicate the directions in which the spray nozzles are inclined from the vertical line on the retaining board. The inclination angle is also set to about 30° from the vertical line in this working example, as well.

From among these spray nozzles, ones that are spraying gas from the beginning are the guiding gas and flotation gas spray nozzles, [10] and [11], of said first group, and the gas of this group is always being sprayed during operation. Next, when the wafer [2] is placed on the right end of Fig. 3 between said two rows of guiding gas spray nozzles [10] after causing spraying of the positioning gas of the third group from [12-2] and the transfer gas of the fourth group from [9], the wafer [2] floats from the retaining board [1] by about 0.5mm by means of the flotation gas, and while being guided onto the center line of the transfer path by the guiding gas, it becomes transferred by the transfer gas and reaches a point directly above the discharge port [3] that is at the center portion of Fig. 3. Once this location is reached, the advancement is stopped by means of the flow of the positioning gas of the third group that is already being sprayed from [12-2]. At this time, at the same time as the stopping of the spraying of the transfer gas of the fourth group, the positioning gas of the second group and the rotation gas of the fifth group are sprayed from the

spray nozzles [12-1] and [6], respectively. In this condition, the wafer [2], while floating from the retaining board [1] due to the flotation gas of the first group, is positioned by the guiding gas of the first group and the positioning gas of the second and third groups to a location that is centered directly over the discharge port [3], and rotation is started by means of the rotation gas of the fifth group.

Furthermore, since the infrared irradiation devices [8] have already been turned on at this time, the wafer [2] that is rotating at a fixed location while floating is rapidly and evenly heated from both the top and bottom surfaces. /79

Next, in order to unload the wafer [2] after performing the heat treatment for a prescribed amount of time, the spraying of the positioning gas of the third group is stopped, and at the same time, the spraying of the transfer gas of the fourth group is started. This moves the wafer [2] to the left of Fig. 3 by means of the positioning gas of the second group being sprayed from [12-1] and the transfer gas of the fourth group. After this, the wafer [2] will be moved to the left end by means of only the transfer gas.

In addition, the rotation gas of the fifth group may either be sprayed only when the wafer [2] is rotated or may be sprayed at all times in the same manner as the flotation gas and guiding gas of

the first group.

In the case of this second working example, if the wafer supply cassette and wafer storage cassette mentioned in Tokugan No.57-103524 "Continuous Heat Treatment Method and Device for Semiconductor Substrate" applied for by the present applicant are provided on the right end and left end of the traveling interval of the wafer [2] shown in Fig. 3, automation of the cassette-to-cassette operation becomes easily possible.

In the above manner, since the wafer [2] is floating by means of the sprayed gas in the device of this invention, there is no partial heat loss caused by contact with solid matter. Moreover, since it rotates during a prescribed heat treatment period, the uneven temperatures on the surface of the wafer [2] caused by variations in the locations and irradiation amounts of the infrared irradiation devices [8] can also be made even. Moreover, since flotation transfer is possible, automation of a device that performs heat treatments continuously can also be easily achieved. Moreover, since it is not necessary to heat up portions having a high heat capacity, rapid heating and rapid cooling can also be easily carried out, and thus, the practical effects are extremely significant.

4. Brief Description of the Drawings

Figure 1 is a drawing of a vertical cross section that goes through the center point of the retained position of a wafer of the device of one working example of the present invention. **Figure 2** is a layout drawing of the gas discharge port and spray nozzles on the retaining board of the device of Fig. 1. **Figure 3** is a layout drawing of the gas discharge port and spray nozzles on the retaining board of the device of another working example of the present invention.

In the drawings: [1] is a retaining board, [2] is a wafer, [3] is a discharge port, [4] is a positioning gas spray nozzle, [5] is a flotation gas spray nozzle, [6] is a rotation gas spray nozzle, [7] is an upper lid, [9] is a transfer gas spray nozzle, [10] is a guiding gas spray nozzle, [11] is a flotation gas spray nozzle, and [12-1] and [12-2] are positioning gas spray nozzles.

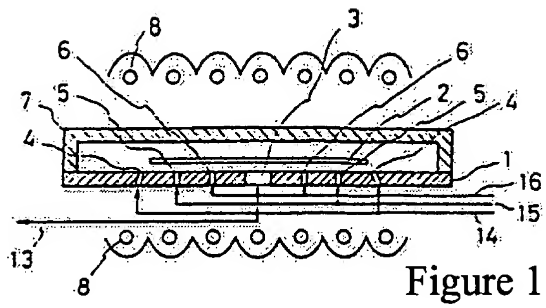

Figure 1

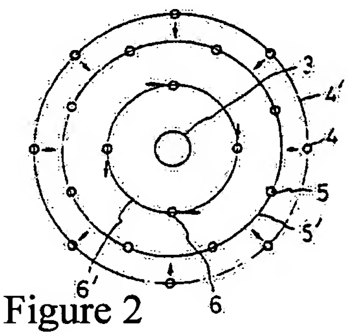

Figure 2

Figure 3